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THE HURON AND CLEVELAND SHALES OF NORTHERN OHIO[1]

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INTRODUCTION

Two articles in a recent number of the *American Journal of Science* devoted largely to a consideration of the Ohio shale in northern Ohio[1] appear to make it important that a detailed description of the Huron shale as exposed at its typical locality on the Huron River in northern Ohio be published. This is termed the typical locality because Dr. Newberry stated that "this [Huron] is the shale which forms the banks of the Huron river at Monroeville and below. . . . . The Huron shale in some places contains many concretions of impure limestone, of which hundreds may be seen at Monroeville, where they have washed out of the river banks."[2] Later he wrote: "I have called this in Ohio the Huron shale, because it forms for a long distance the banks of the Huron River, and as it represents several distinct strata in New York and Pennsylvania, it could not with propriety take the name of either of them."[3] Dr. Newberry first published the name Huron shale in 1870 and stated that "its outcrop forms a belt from ten to twenty miles in width, reaching from the Lake shore at the mouth of the Huron River, almost directly south to the mouth of the Scioto."[4]

The area under discussion is shown on the sketch map of Fig. 1 on which the location of the several sections is indicated by an x.

SECTIONS AND DESCRIPTIONS OF HURON SHALE

BASAL DEPOSITS

Slate Cut section.—The banks of the Huron River from Milan down to its mouth at Huron are composed of glacial and alluvial deposits and the base of the shale is not shown on the river. It is exposed, however, in Slate Cut on the Lake Shore & Michigan Southern Ry. about 4 miles northwest of the Huron River and a

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[1] E. O. Ulrich, "The Chattanoogan Series with Special Reference to the Ohio Shale Problem," *American Journal of Science*, 4th ser., XXXIV (August, 1912), 157–83. Edward M. Kindle, "The Stratigraphic Relations of the Devonian Shales of Northern Ohio," *ibid.*, pp. 187–213.

[2] *Geological Survey of Ohio*, II (1874), 189.

[3] *Monograph U.S. Geological Survey*, XVI (1889), 57, 58.

[4] "Report of Progress in 1869 (1870)," *Geological Survey of Ohio*, p. 18, or (1871 ed.) 19.

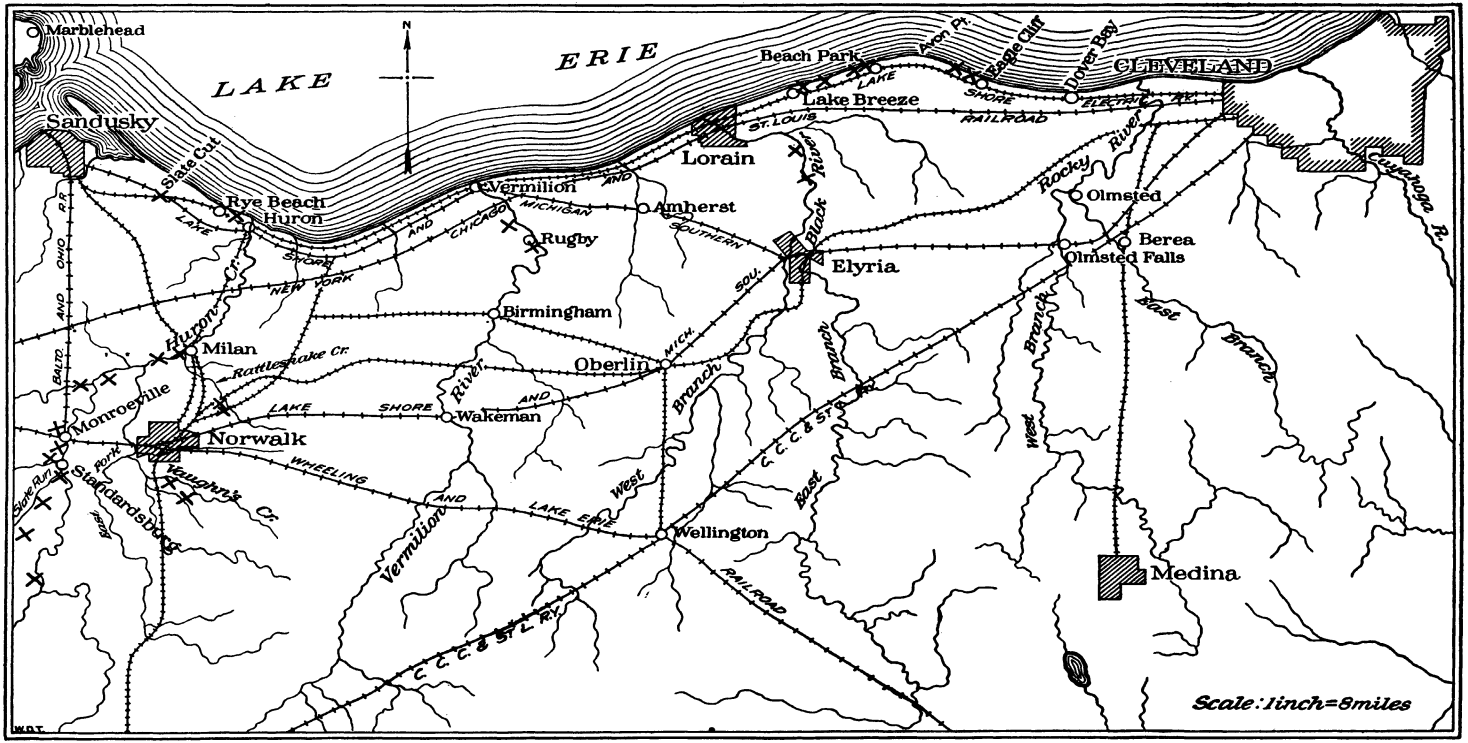

FIG. 1.—Sketch map from Cleveland to the Huron River on which the location of the sections is indicated by the ×-sign

little east of stop 8 on the Lake Shore Electric Ry. The section on the northern bank of the cut is as follows:

No.	Section of Slate Cut	Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
4.	*Huron shale:* Black, bituminous, hard, slaty shale. At one part of the cut is a bluish-gray lens from 2½ in. to 3 in. thick and in the blackish shale just above are Lingulas. Toward the eastern end and some 5 ft. above the base is a spherical concretion. On this bank 8 ft. 3 in.+ are shown and on the southern 9 ft. 6 in. of shale which does not reach the subjacent limestone	8	3+	10	6−
3.	*Prout limestone:*[1] The upper 1¼ in. contains a large percentage of marcasite, and the entire layer as weathered is greatly ironstained		3	2	2
2.	Rather shaly layer containing crinoid segments and some other fossils		1±	1	11+
1.	Massive layer of rather dark gray, dense, and very hard limestone. Contains cup corals, crinoid segments, and some other fossils. The calcareous material of the corals has been largely replaced by silica. Dip of top of this layer between 1½° and 2°, 20° S. of E. Bottom of cut	1	10½	1	10½

This section is shown in Fig. 2 and it has been briefly described by Dr. Stauffer who stated that "the Prout member of the Olentangy is nicely exposed with the overlying Huron shale."[2]

Shore of Lake Erie.—On the shore of Lake Erie about north of the house of Dr. J. P. Esch and stop 15 of the Lake Shore Electric

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[1] This name was proposed for the limestone between the superjacent black Huron shale and the subjacent gray Olentangy shale by the writer in October, 1903, and the name published in December of that year (*Ohio Naturalist*, IV, 47). The typical locality is Deep Cut on the Baltimore & Ohio R.R., 6 miles south of Sandusky and about one mile north of Prout, in which 5 ft. of limestone are now shown (see *Geological Survey of Ohio*, 4th ser., Bulletin 10, pp. 119, 120), although in Dr. Newberry's section, which was probably made when the cut was new, it is given as 10 ft. (see *ibid.*, II (1874), 190, No. 2 of section). This limestone is known only in the northern part of the state and it is probably well to consider it as a lentil or member of the Olentangy formation as has been done by Dr. Stauffer (*ibid.*, Bulletin 10, pp. 117, 119, 120 and Pl. IX).

[2] *Ibid.*, p. 122.

Ry., from 4 to 6 in. of black shale are shown. Some of it is more or less mottled with gray lines and splotches and under water is apparently a light-gray layer. The shale must form the bottom of the lake for some distance out from the shore, and numerous spherical concretions partly covered by water occur. These concretions extend along the lake shore for about one-half mile and are about midway between Huron and Rye Beach. This is the locality where Dr. Kindle, on the authority of Professor E. B. Branson, reports *Dinichthys herzeri* Newb.[1] and which Branson gave as from 50 to 60 ft. above the base of the Huron.[2]

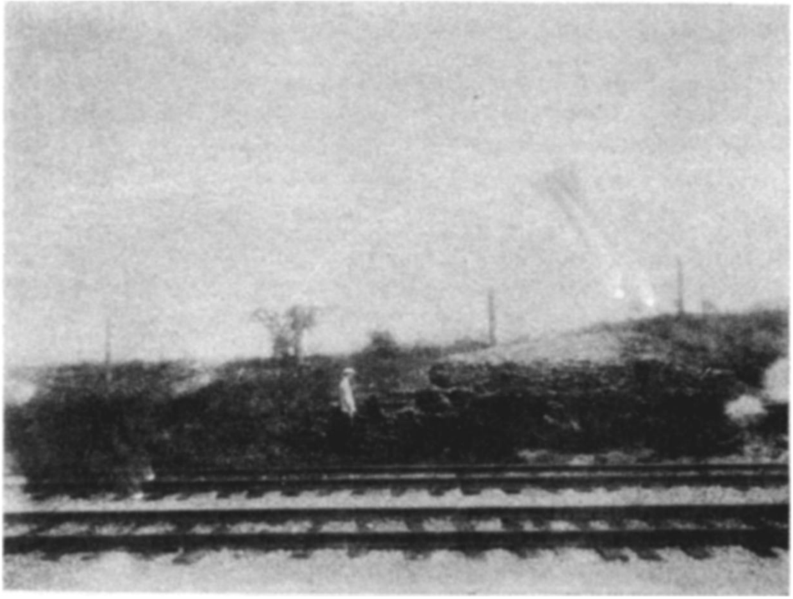

FIG. 2.—Slate Cut showing the upper part of Prout limestone and lower Huron shales. Mr. Roderick stands on top of Prout limestone.

SECTIONS ON THE HURON RIVER

Milan section.—The most northern outcrop of Huron shale, as well as the lowest stratigraphically, on the Huron River is on its western bank a short distance south of the river bridge at Milan and 7¾ miles south of Slate Cut. The entire length of the bank was studied and the following section prepared after such examination. Toward its upper end, the rocks dip steeply upstream so that the lower part of this section is covered. The lower and middle portions show the lower part of the section. All except the lowest part of the following section was measured near the middle of the bend and the lowest portion farther north.

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[1] *American Journal Science*, 4th ser., XXXIV, 211.

[2] *University of Missouri Bulletin*, Science ser., II, No. 2 (October, 1911), p. 25

SECTION ABOVE MILAN RIVER BRIDGE

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
13.	Black, bituminous, fissile shale which is slaty before it weathers	6	..	18	10½
12.	Blue shale, 1 to 2 in	..	1½±	12	10½
11.	Black shale	..	4	12	9
10.	Blue shale	..	1	12	5
9.	Black shale	..	9	12	4
8.	Blue, argillaceous shale containing disk-shaped concretions	1	6	11	7
7.	Black, bituminous, fissile shale as weathered which is hard and slaty when freshly exposed. Contains large numbers of spherical, calcareous concretions, an occasional somewhat disk-shaped one, and small marcasite concretions. The spherical concretions range in size from 6 in. to 3 ft. 6 in. vertical measurement and from 9 in. to 4 ft. horizontal. They show beautifully the arching of the shale above the concretion and its depression below, indicating their aggregation after the formation of the shale. Stems of probably *Pseudobornia inornata* (Dawson) White were found at 3 ft. 1 in. and 4 ft. 3 in. below the top of this zone, which is believed to be the one in which Dr. Kindle found the long fragment of a trunk of the above species.[1] Zone varies in thickness from 7 ft. 3 in. to 8 ft. 6 in	8±	..	10	
6.	Blue to olive, gritty shale, 2½ to 3 in	..	3	2	1
5.	Black shale	..	2½	1	10
4.	Blue shale, 2½ to 3 in	..	3	1	7½
3.	Black shale	..	3½	1	4½
2.	Blue shale, ¾ to 2½ in	..	2±	1	1
1.	Black shale to river level	..	11	..	11

[1] *American Journal Science,* 4th ser., XXXIV, p. 209.

At the lower end of the cliff only the black shale of zone No. 7 is shown where it is 8 ft. 2 in. thick. For some distance farther up the river the rocks rise so that the zones beneath this concretionary black shale are shown; but after passing the bend they dip down again so that at the southern end of the cliff only the upper black shale is shown. A section at this locality is given by Dr. Kindle in which the 9-ft. zone of "fissile black shale with numerous large spherical concretions"[1] obviously corresponds to zone No. 7 of the above section.

McGue section.—

SECTION ON THE JAMES MCGUE FARM

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
15.	Bowlder clay and other drift	..			
14.	Blue shale; but entire thickness of zone not shown	..	4±	10+	..
13.	Black shale from ½ to ¾ of an in. thick	..	½+	9	9
12.	Blue shale	..	5	9	8½
11.	Black shale	..	2½	9	3½
10.	Blue shale	..	2−	9	1
9.	Black shale	..	3¼	8	11
8.	Blue shale	..	9¼	8	7¾
7.	Black shale	2	..	7	10½
6.	Blue shale; toward the lower end of the bank two somewhat irregular-shaped concretions occur	..	11½	5	10½
5.	Black shale	..	5	4	11
4.	Blue shale with an occasional very thin layer of black shale near the center	..	6½	4	6
3.	Black shale	..	3	3	11½
2.	Blue shale	..	3½	3	8½
1.	Black, hard, bituminous, fissile shale which is rather massive and slaty before weathering. Near the top are numerous spherical concretions which were seen only in the upper part of the zone. It also contains marcasite concretions. Two ft. 4 in. are shown where the above section was measured and 3 ft. 5 in. at upper end of cliff, but not reaching the base of the zone	3	5+	3	5+

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[1] *Ibid.*, p. 201.

Zone No. 1 of the above section is believed to be the continuation of the black shale at the top of the Milan section (zone No. 13 of that section), but somewhat higher stratigraphically and showing the horizon with spherical concretions which is probably stratigraphically higher than the exposed black shale at the top of the Milan section. Above this zone of rather thick black shale occur alternating zones of blue and black shale which have a considerable total thickness. The next three sections measured in ascending the river, one on the Will Hipteley farm on the eastern side and two on the western side on the Fred Heckelman and Mrs. Helen Andrews farms, do not add very much to the general section of the Huron River; consequently they will be omitted in this article. They are important, however, in tracing the zones shown in the McGue section up the river to the section at Enterprise which will now be described.

Enterprise section.—A steep cliff forms the western bank of the Huron River[1] at the former hamlet of Enterprise below the P. J. Schaffer bridge. The bank is difficult to climb but the following section was measured just below the William H. Newton house by Mr. Tom G. Roderick:

SECTION OF WESTERN BANK OF HURON RIVER AT ENTERPRISE

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
21.	Black, hard, bituminous, fissile shale which projects beyond the lower shales as exposed to the north of the middle of this bank. Thickness estimated as from 5 to 6 ft.............	5+	..	60±	
20.	Mainly blue, argillaceous shale; but with some layers of black shale from 1 to 3 in. thick. On the high bank on the opposite side of the river, above the Schaffer bridge, disk-shaped concretions occur at about the top of this zone....	32	6	54	9
19.	Black shale..............................	3	4	22	3

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[1] One and three-fourths miles above the Milan River bridge are the forks of the Huron River, which are named West Fork and East Fork on the Sandusky quadrangle of the topographic map. The West Fork is the larger, and in accordance with the usage of Dr. Newberry and at least many of the inhabitants of that region the writer considers the West Fork the continuation of the Huron River and so uses it in this article.

No.		Thickness		Total Thickness	
		Ft.	Ins.	Ft.	Ins.
18.	Blue shale	..	11½	18	11
17.	Black shale	..	10	17	11½
16.	Blue shale	2	2	17	1½
15.	Black shale	..	1½	14	11½
14.	Blue shale	..	6	14	10
13.	Black shale	..	1	14	4
12.	Blue shale	..	4	14	3
11.	Black, hard, bituminous, slaty, fissile shale	2	3	13	11
10.	Blue shale containing irregular more or less disk-shaped concretions	1	..	11	8
9.	Black shale	..	7	10	8
8.	Blue shale	..	7	10	1
7.	Black shale	..	4	9	6
6.	Blue shale	..	3½	9	2
5.	Black, bituminous, hard, slaty, fissile shale containing some large spherical concretions. There are two small ones at almost the top of this zone	7	10½	8	10½
4.	Blue, rather argillaceous shale	..	8	1	..
3.	Black shale	..	2	..	4
2.	Blue shale a little farther upstream than the concretions	..	2+	..	2
1.	River level with rather irregular concretions in blue shale	..	..	..	..

In the above section the black shale containing spherical concretions of zone No. 5 is believed to be the continuation of the lower black shale containing similar concretions as exposed on the western bank of the Huron River on the Andrews, Heckelman, and McGue farms, and then with the upper black shale of the Milan section. Above this black-shale zone are alternating strata of blue and black shale before reaching a blue-shale zone a foot or more in thickness containing irregular or disk-shaped concretions above which is a conspicuous black-shale zone. This black-shale stratum is 2 ft. 3 in. thick in the Enterprise section, 2 ft. 3 in. in the Andrews, 2 ft. 1½ in. in the Heckelman, and 2 ft. in the McGue section. The section by Dr. Kindle "near the bridge 3 miles southwest of Milan"[1] apparently is at or near the locality where the above section was measured.

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[1] *Op. cit.*, p. 201.

Farther up the river near the township line of Oxford Township on the Joe Schlacter farm is another cliff on the western bank of the Huron River showing practically a section of the same portion of the Huron shale as the one just described at Enterprise. Very near the base of the section is an 8-ft. zone of black fissile shale containing spherical concretions, which apparently corresponds to zone No. 5 of the Enterprise section, which is 7 ft. 10½ in. thick. Above this black shale in the Schlacter cliff are alternating strata of blue and black shales with a total thickness of 44 ft., when a zone of black shale capping the cliff is reached, 8 ft. or more of which are shown. The corresponding interval between the two conspicuous zones of black shale in the Enterprise section has a thickness of 43 ft. 10½ in.

Seymour Creek section.—The zone of black shale, the lower part of which caps the cliff at Schlacter's and Enterprise, is better shown on Seymour Creek just north of the schoolhouse of Subdistrict No. 6 of Ridgefield Township.

SECTION OF SEYMOUR CREEK NEAR SCHOOLHOUSE NO. 6

No.		THICKNESS Ft.	TOTAL THICKNESS Ft.
2.	Black, bituminous, fissile, hard slaty shale. A large globular or spherical concretion is imbedded in this shale, the base of which is about 1½ ft. above the base of this zone. The top of this zone is not shown, but 24½ ft. of the black shale were measured on the bank......................	24½+	52½
1.	Blue shale alternating with thin bands of black shale. In the upper part of the blue shale are numerous large concretions which are lenticular or disk-shaped. There are from 8 to 10 in the vicinity of the bend in the creek and one in the stream is 5 ft. 8 in. by 5 ft. 6 in. A twin one on the bank is 11 ft. long by 6 ft. wide. Five± ft. of this zone are shown at this locality and from its top down to the bridge on the lower road there are shown about 28 ft. of the alternating blue and black shales according to a measurement by Professor J. E. Hyde.........................	28	28

This section is shown in Fig. 3, in which the man is indicating with the hammer the contact of the black shale (zone No. 2) which forms the upper part of the bank, and blue shale with thin bands of black which forms the lower part. Two of the characteristic lenticular-shaped concretions of the soft blue shale are shown a little above water level.

The upper black shale, zone No. 2 of the above section, may be followed up the Huron River to Monroeville, where its top apparently is reached on the bank above the dam and the Main Street bridge; but the writer is not so certain of this identification as of that of most of the other zones of this general section. At this locality stems of *Calamites* (*Pseudobornia* [?]) are not infrequent in the black shale of this zone below the Main Street bridge.

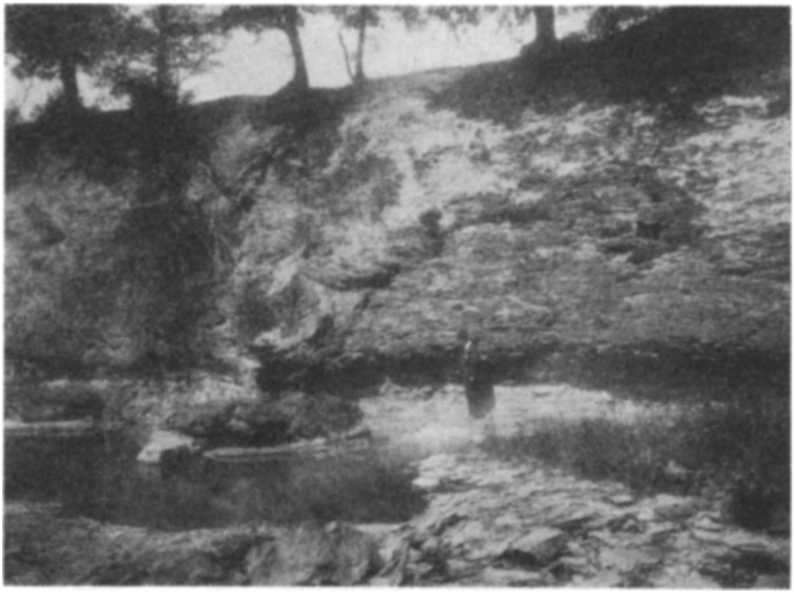

FIG. 3.—Black and blue Huron shales on Seymour Creek, the contact indicated by hammer. Spherical concretion in lower part of black shale and lenticular concretions in blue soft shale near water level.

Sections in Monroeville and vicinity.—There is a shale bank on the northern side of the Huron River between the dam and Stand Pipe and below the Lake Shore Electric Ry. bridge. The bank was measured near the house of Mr. Rivere Needham, where the following section was obtained:

MONROEVILLE SECTION NEAR HOUSE OF RIVERE NEEDHAM

No.		THICKNESS Ft.	TOTAL THICKNESS Ft.
9.	Partly covered upper part of bank. Blue and black alternating shales	8+	$18\frac{1}{2}$
8.	Blue shale	$\frac{3}{4}$	$10\frac{1}{2}$
7.	Black shale	$\frac{3}{4}$	$9\frac{3}{4}$
6.	Dark-blue shale	$\frac{5}{6}$	9
5.	Black shale	$\frac{1}{4}$	$8\frac{1}{6}$
4.	Dark-blue shale, $3\frac{1}{2}$± in. thick	$\frac{1}{4}$+	$7\frac{1}{12}$
3.	Black shale	$\frac{1}{6}$	$7\frac{2}{3}$
2.	Dark-blue shale	$\frac{1}{4}$	$7\frac{1}{2}$
1.	Black shale to water level	$7\frac{1}{4}$	$7\frac{1}{4}$

On the western side of the Huron River above the Lake Shore & Michigan Southern Ry. bridge in Monroeville is a 10— ft. ± bank composed mainly of black shale, but with a little blue shale. The upper part of the bank overlying the black shale shows zones of blue- to olive-colored shale, perhaps 6 in. thick, alternating with black shale. Toward the lower end of the bank are numerous rather irregular to lenticular-shaped concretions a little above river level and a little farther up stream similar concretions occur in its bed. This is apparently the continuation of the lower portion of the Needham section; although its stratigraphic position was not determined as accurately as might be desired. The base of the section is vertically probably not more than 8 ft. above the top of the rocks studied below the dam.

One-fourth mile farther up the river and a little below the house of William Schug is a shale bank from 27 (hand-level) to 30 (barometer) ft. high.

SECTION ON HURON RIVER AT WILLIAM SCHUG'S

No.		THICKNESS Ft.	TOTAL THICKNESS Ft.
4.	Black shale near top of bank which is considerably broken	2+	27
3.	Blue shales alternating with thin layers of black shale, the blue predominating. In the lower part of the blue shales are large lenticular concretions	$19\frac{2}{3}$±	25
2.	Stratum of massive, black shale	$1\frac{5}{6}$	$5\frac{1}{3}$
1.	Black shale alternating with blue to river level, about $3\frac{1}{2}$ ft. thick	$3\frac{1}{2}$±	$3\frac{1}{2}$

The shales in the lower part of this bank are dipping upstream (S. 20° W.) at the rate of between 2° and 4°, so that the nearly 10 ft. of black shale shown on the lower bank above the Lake Shore & Michigan Southern Ry. bridge have been carried beneath water level at this locality.

At the three corners, about 1 mile south of Monroeville, is a road quarry where the following section was measured:

SECTION AT THREE CORNERS SOUTH OF SCHUG'S

No.		Thickness Ft.	Total Thickness Ft.
2.	Continuous hard, slaty, black shale containing *Protosalvinia* (*Sporangites*)	10⅔	16
1.	Alternating black and blue shales as shown below the quarry	5⅓	5⅓

The barometer gave the base of the continuous black shale in the above section as 5 ft. lower than the top of the bank at Schug's. The dip varies from 1½° to 2°, N. 60° E. The continuous black shale, zone No. 2, of this section apparently is the continuation of the broken black shale at the top of the bank in the section below Schug's house.

Standardsburg sections.—The hamlet of Standardsburg is located on the Huron River 1½ miles south of Monroeville. The black shale on the western bank of the river a few rods above the highway bridge contains two very large concretions and the following section was measured just below the upper one on the land of Mr. William Cook:

SECTION ON HURON RIVER AT STANDARDSBURG

No.		Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
12.	Black, hard slaty shale in which are the two very large spherical concretions. The base of the upper one is only 8 in. above the base of this zone. The vertical diameter of the upper one is about 6 ft. and one-half the distance around it is 17 ft. so that its circumference is about 34 ft. This concretion is shown in Fig. 4	5	1	8	8½
11.	Blue shale which is rather hard	..	6½	3	7½
10.	Black shale	..	5¼	3	1
9.	Blue shale	..	1¾	2	7¾
8.	Black shale in places split by ½-inch layer of blue shale	..	2¼	2	6

Section on Huron River at Standardsburg—*Continued*

No.		Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
7.	Blue shale	..	10¾	2	3¾
6.	Black shale	..	1¾	1	5
5.	Blue shale	..	7½	1	3¼
4.	Black shale	..	2¼	..	7¾
3.	Blue shale	..	1½	..	5½
2.	Black shale	..	1	..	4
1.	Blue shale to river level	..	3	..	3

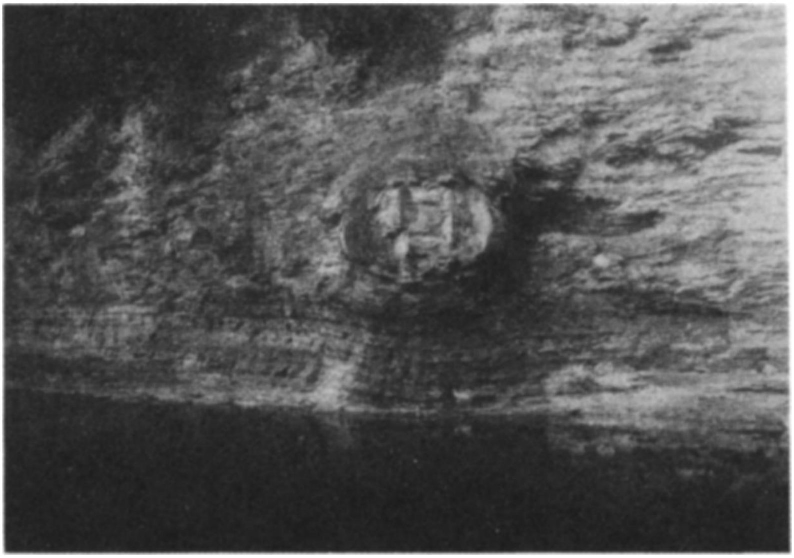

Fig. 4.—Large, spherical concretion in Huron shale on bank of Huron River at Standardsburg.

Zone No. 12 of the above section evidently corresponds to the lower half of zone No. 2 in the quarry at the three corners to the north of Standardsburg. The spherical concretions in the upper black shale at this locality are the largest that the writer has seen in northern Ohio. The black shales show very clearly that they have been moved from their original position by the formation of the concretions, so that the shales are arched above the concretions and correspondingly pushed down beneath them.

A few rods above the section just described, Slate Run enters Huron River from the southwest and near its mouth the south-eastern bank is steep and rather high. A section of this bank is as follows:

SECTION OF SLATE RUN AT STANDARDSBURG

No.		Thickness Ft.	Total Thickness Ft.
2.	Apparently all hard, black, slaty shale 22 ft. or more thick. No concretions occur in this bank; but farther up the stream where it is crossed by the north-and-south road there is a large spherical concretion in place in the shale and several occur above the creek level............................	22+	23
1.	Top of blue, slaty shale, which corresponds to zone No. 11 of the previous section, about 1 ft. above water level. Blue shale with black shale below to creek level.............	1	1

In the bed of Huron River a short distance east of the mouth of Slate Run are large, somewhat lenticular concretions. On the northern bank of the river at this locality, which is opposite the house of Mr. Charles Burgel, from 15 to 18 ft. of hard, black shale are shown.

SLATE RUN SECTIONS

Sections near Pontiac.—On the Huron River to the south of Standardsburg and above the cliff just mentioned, the banks are mainly alluvial and drift. The shales are much better exposed along Slate Run, which is a southwestern tributary of Huron River, and this general section is continued up that run.

The southern bank of Slate Run, at the north-and-south highway bridge and below the railroad at Pontiac, shows 10 ft. of hard, slaty, black shale and below the bridge the bank is higher, apparently showing from 12 to 15 ft. of black shale. The barometer, with an interval of 37 minutes between the readings, gave the level of Slate Run at this bridge as 25 ft. higher than its mouth at Standardsburg. This apparently shows that this black shale is a continuation of the zone forming the greater part of the cliff at the mouth of the run and is probably stratigraphically higher.

Again, where the highway running directly west from Pontiac crosses Slate Run, black shale forms the floor of the stream above the bridge, and below it there is a bank 12 ft. high composed entirely of black shale. The barometer with an interval of 33 minutes between the readings, gave Slate Run as 15 ft. higher than at the former bridge. This appears to indicate that this zone of hard, slaty, black shale on Slate Run has an approximate thickness of some 50 ft.

Section on Peter Hay farm.—Farther south on the farm of Peter Hay on the western side of Slate Run in Sherman Township is a bank composed of alternating black and blue shales which evidently overlies the one of hard, black shale already described along the lower course of this run. The section begins at the northern end of the bank and continues on up stream as follows:

SECTION OF SLATE RUN BANK ON FARM OF PETER HAY

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
12.	Drift and alluvial material containing a considerable amount of worked-over black shale ..	8	..	17	6—
11.	Black, shattered shale....................	1	6	9	5¾
10.	Zone more or less disturbed but composed of blue and black shale....................	2	5½	7	11¾
9.	Black shale....................	..	8½	5	6¼
8.	Blue shale....................	..	8½	4	9¾
7.	Black shale....................	..	1¾	4	1¼
6.	Blue shale....................	..	3½	3	11½
5.	Black, slaty shale....................	1	4	3	8
4.	Blue shale containing very irregular concretions of large size. One of them, very irregularly shaped, is 9 ft. long and lies imbedded in the blue shale; another one is about 7 ft. long	1	3	2	4
3.	Black shale, 2½ to 3 in. thick....................	..	3	1	1
2.	Blue shale....................	..	4	..	10
1.	Black, hard shale at northern end in bed of run....................	..	6±	..	6

In the above section all the blue shale weathers into small pieces. The layers are more or less disturbed and it is difficult to estimate the dip accurately; but near the southern end it is about 2° to the northeast. Farther up the stream the banks in general are low and alluvial and apparently no shales are exposed that are much higher stratigraphically than those on the Peter Hay farm.

UPPER PART OF HURON RIVER

As already stated, the banks of the Huron River above Standardsburg are generally alluvial and drift. The bed of the river, however, where the east-and-west road west of Macksburg crosses it, is apparently composed of black shale. Again, at the next bridge to the south crossing the river in the southwestern part of Peru Township and about 1¾ miles northeast of Havana, is a bank of slaty, black shale. This bank extends for a short distance on the northern side of the river both above and below the highway bridge and is 10 ft. or so in height. A few rods farther down stream where the river turns to the north is another bank of black, slaty shale on its western side, perhaps a little more than 10 ft. in height. Neither concretions nor layers of cone-in-cone were seen in these banks of black shale. All of the banks farther south on Huron River in Greenfield Township that were visited are composed of alluvial and drift deposits until a point southeast of Steuben is reached where outcrops of Berea sandstone and perhaps Bedford shale occur. Apparently the bank of black shale in the southwestern corner of Peru Township is the last black shale exposed on Huron River and it probably belongs in the Huron.

GENERAL SECTION ON SLATE RUN AND HURON RIVER

A general section of the shales from the upper bank on Slate Run on the Peter Hay farm down this run and Huron River to the lowest outcrop on the river near Milan has been prepared. The section is as follows and the column on the right indicates the location of each zone:

GENERAL SECTION ON SLATE RUN AND HURON RIVER

TOTAL THICKNESS	THICKNESS OF ZONE	Location and Description of Zone
0′	10′	Black and blue shale of Slate Run on Peter Hay farm.
10′	50′±	Black, hard slaty shale on Slate Run. Large spherical concretions in lower part.
60′	25′+	Blue and black shales on Huron River at William Schug's.
85′	25′	Black shale from Monroeville to Seymour Creek. Spherical concretions in lower part.
110′	47′	Blue and black shale in Enterprise section. Irregular lenticular to disk-shaped concretions in upper and lower part.
157′	8′	Black shale near base of Enterprise section. Spherical concretions.
165′	3′−	Blue and black shale near Milan. Irregular disk-shaped concretions.
168′	8′±	Black shale containing stems of *Pseudobornia*. Spherical concretions. Lower black shale of section near Milan.
176′	2′	Blue and black shale to river level near Milan. Lowest shale outcrop on Huron River.
178′		

Dr. Kindle states:

> The lower part of the black shales above the Olentangy shale is everywhere characterized in Ohio by spherical concretions often of large size. Concretions of this type are entirely unknown in the Cleveland shale both in its typical area and outside of it. On the other hand, in the region where the Cleveland is typically developed the thin limy bands with cone-in-cone structure are common. This type of rock has never been found associated with the spherical concretions. . . . . It is proposed, therefore, to limit the term Huron shale to those beds of the Ohio shale exposed on the Huron River, at Rye Beach and elsewhere, in which the spherical concretions occur and the Cleveland shale to the higher beds in which they do not occur and in which the cone-in-cone structure does occur.[1]

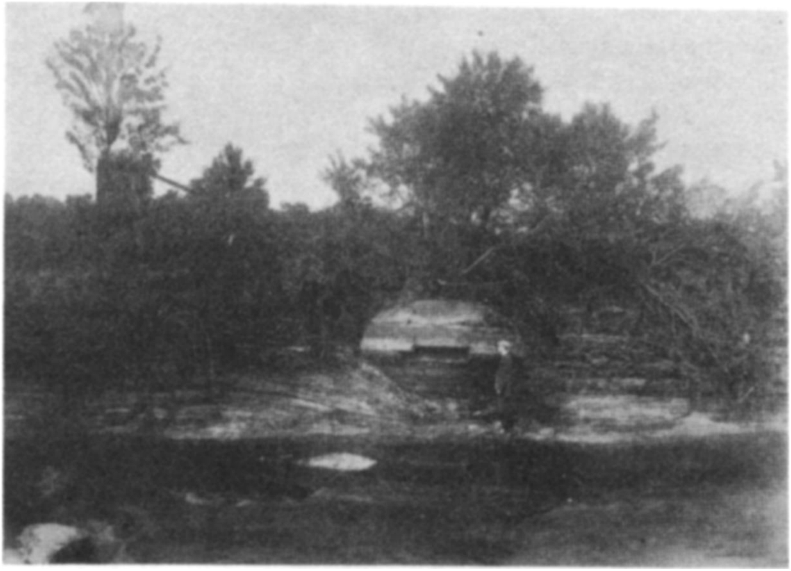

FIG. 5.—Huron shale on East Fork of Huron River, below Jacobsburg. Uppei part of cliff (15± ft.), all black shale containing spherical concretion near its base with vertical diameter of 5 ft. Blue to bluish-black shale alternating with black from 3¼ in. below base of concretion for 9 ft. to river level.

In northern Ohio the writer has not seen any spherical concretions in the Cleveland shale or cone-in-cone layers in the Huron shale. In central Ohio, however, thin, limy, lenticular layers with cone-in-cone structure occur at least in the lower part of the Ohio shale, as for example in "the Narrows" and other glens north of Worthington. In the general section of Huron River and Slate Run large spherical concretions occur in the lower part of the highest thick zone of black shale as well as in all the lower zones of black shale with a thickness of 8 ft. or more. It appears certain, therefore, that all of the rocks composing this section belong in the Huron shale. This section perhaps does not include the highest black shale seen on the Huron River in the southwestern corner of Peru Township in which nothing was seen to show whether it belongs in the Cleveland or the Huron shale. This general section does not extend to the base of the Huron shale, which is shown in Slate Cut on the Lake Shore & Michigan Southern Ry. some 7¾ miles north of the cliff just above Milan, where the lowest outcrops of the Huron shale on Huron River are shown. The general section gives 178 ft. of the Huron shale on Slate Run and Huron River and the thickness of the mostly covered interval from the lowest outcrops of the section to the base of the formation in Slate Cut is not known. If to the 178 ft. of Huron shale in the general section the thickness of the interval to the base of the formation be added, it will certainly give a thickness of over 200 ft. for the Huron shale on the Huron River. Dr. Kindle estimated that "the Huron will have in the Huron section a thickness of probably 100 feet."[1] A thickness of over 200 ft. for the Huron shale is corroborated by the record of the Citizens' Well, No. 1 at Norwalk, about 5 miles east of Monroeville. The well is located by the side of the Wabash R.R. just east of the Norwalk Gas Plant and its mouth is 40 ft. higher than the level of East Fork Huron River at the old waterworks. The first 85 ft. of the well was in drift,[2] and the Prout limestone which directly underlies the Huron shale in this region was reached at a depth of 288 ft. according to the writer's notes. From a study of the outcrops in the vicinity of Norwalk it appears that the black shale struck in this well at a depth of 85 ft. is stratigraphically below the base of the Cleveland shale and consequently all of the 203 ft. of shale down to the Prout limestone belong in the Huron shale.

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[1] *American Journal of Science*, 4th ser., XXXIV (August, 1912), 198, 199.

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[1] *Ibid.*, p. 199.

[2] Dr. Stauffer in his record of this well gives only 76 ft., composed of samples Nos. 1–5, as drift (*Geological Survey of Ohio*, 4th ser., Bulletin 10 [1909], p. 117); but in the writer's notes on an examination of the samples made on September 11, 1905 he gave samples Nos. 1–6 as drift.

SECTIONS AND DESCRIPTIONS OF CLEVELAND SHALE AND RELATED FORMATIONS

FROM NORWALK TO BLACK RIVER

Sections on Vaughn's Creek south of Norwalk.—As already stated, Dr. Kindle has limited the term Cleveland shale to the higher beds of the Ohio shale in which the spherical concretions "do not occur and in which the cone-in-cone structure does occur."[1] So far as the writer's observations have gone, this appears to be true of the deposits in northern Ohio and he saw no cone-in-cone lenses in the shales on Huron River and Slate Run. The highest outcrops of black shale, however, south and east of Norwalk contain lenses of impure limestone with cone-in-cone structure. The following section on the northern bank of Vaughn's Creek, about 1¾ miles south of the court house in Norwalk and a few rods above the Sandusky, Norwalk & Mansfield trolley bridge, was measured:

SECTION ON VAUGHN'S CREEK SOUTH OF NORWALK

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
18.	Black, hard, slaty shale. Farther up the creek 20+ ft. of this shale are shown with a little cone-in-cone structure	10±	..	25	9
17.	Dark gray shale	..	4	15	9
16.	Black shale	..	6	15	5
15.	Blue shale	..	8	14	11
14.	Black shale	2	2	14	3
13.	Blue shale, from 3 to 3¼ in. thick	..	3	12	1
12.	Layer of cone-in-cone, lens-shaped masses thinning out and reappearing again at the same horizon, from 0 to 2¼ in. thick	..	2±	11	10
11.	Black shale from 5½ to 6 in. thick	..	5½+	11	8
10.	Gray shale, from 2 to 3 in. thick	..	2½+	11	2½
9.	Black shale	..	3	11	0
8.	Gray shale with some thin layers of black from 16 to 18 in. thick	1	5±	10	9

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[1] *American Journal of Science*, 4th ser., XXXIV, 199.

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
7.	Black shale	..	9	9	4
6.	Blue, argillaceous shale, from 20⅔ to 21 in. thick	1	9−	8	7
5.	Black shale	..	8	6	10
4.	Gray to blue shale	..	4	6	2
3.	Black shale	5	0	5	10
2.	Gray shale	..	2	..	10
1.	Black shale to creek level	..	8	..	8

In the region south and east of Norwalk there is generally a zone of black shale, like No. 18 of the above section, of variable thickness at the top of the Ohio shale, succeeding which, in a few places, is a little of the Bedford shale, but more frequently the Berea sandstone. This irregular thickness of the upper black-shale zone of the Ohio and comparatively little if any of the Bedford formation are due to more extensive erosion before the deposition of the Berea sandstone than occurred in most of Ohio. At part of the localities studied near Norwalk not only is all of the Bedford wanting, but also the upper part of the Ohio or Cleveland shale, so that the Berea sandstone rests on the Huron shale. The writer has described a similar disconformity between the Berea and Bedford formations in central Ohio[1] and in northern Ohio from Rocky River west of Cleveland eastward as far at least as the Grand River Valley,[2] except that the erosion was not so great as in the Norwalk region. There is an example of this disconformity in the immediate vicinity of the section described above. In the bed of Vaughn's Creek and on its northern bank a few rods below the Sandusky, Norwalk & Mansfield trolley bridge is an outcrop of the Berea sandstone at a lower level than the base of the shale section above the bridge. Part of the sandstone is very much contorted with more or less concretionary structure, while some of it is in fairly regular layers. At places there is a bluish, gritty shale below the sandstone and at one point the shale is shown to a depth of 5 ft. and is bluish gray and rather sandy with thin layers of sandstone in it. It is not certain to which formation this shale belongs, although the evidence appears to the

[1] *Journal of Geology*, XX (October—November, 1912), 585–604.

[2] *Geological Survey of Ohio*, 4th ser., Bulletin 15 (1912).

writer to favor its reference to the Berea. Again, a little above the highway and the trolley line, is a knoll a few rods south of the stream, composed of Berea sandstone which shows more or less concretionary structure and ripplemarks. The base of the lowest outcrops in this knoll is 8½ ft. above creek level, while a few rods farther up stream on the opposite bank is the section described above in which the shale runs down into the creek, no sandstone being shown in this section of at least 25¾ ft.

In the various sections studied in the vicinity of Norwalk the writer has regarded the upper zone of black shale of the Ohio, No. 18 of the above section, as the western continuation of the Cleveland shale, or at least as representing part of it. It is perhaps a question at what horizon the line of division between the Cleveland and Huron shales is to be drawn; because if all the shale above the lowest layer of cone-in-cone (zone No. 12 in this section) is to be included in the Cleveland, then its lower part will contain some layers of gray to blue shale. If the base of the lowest layer of cone-in-cone in the above section be considered the base of the Cleveland, then it will extend 4 ft. 1 in. below the base of the upper thick zone of black shale.

Farther up the stream, on its northern (eastern) bank and a few rods below the old Cole quarry, the following section was measured. The old quarry is below the highway passing the J. A. Miller house.

SECTION ON VAUGHN'S CREEK BELOW THE COLE QUARRY

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
11.	Black, hard, slaty shale	18±	..	24	5
10.	Blue shale	..	1½	6	5
9.	Black shale	1	0	6	3½
8.	Black shale but much softer than most of it	..	11	5	3½
7.	Black shale	2	6	4	4½
6.	Blue shale	..	3½	1	10½
5.	Lenticular layer of cone-in-cone varying in thickness from 0 to 3 in.	..	2±	1	7
4.	Black shale	..	6½	1	5¼
3.	Blue shale	..	2¾	..	10¾
2.	Black shale	..	3	..	8
1.	Blue shale to creek level	..	5	..	5

At the upper end of the above section the shales are dipping down stream; but farther down where the high bank of upper black shale occurs they are nearly horizontal. In the above section the base of the lowest cone-in-cone layer (zone No. 5) is 5 ft. below the base of the thick zone of black shale at the top as compared with the 4 ft. 1 in. in the lower section. This bank is apparently the one that Read referred to as some 15 or 20 rods directly north of the Cole quarry, the black shale "in position at the same level [as the quarry]; the strata horizontal and undisturbed."[1] The old quarry was in the Berea sandstone and is apparently another locality on this stream showing channel filling.

Sections on Rattlesnake Creek near East Norwalk.—On Rattlesnake Creek near East Norwalk, about 3 miles northeast of the courthouse in Norwalk, is an excellent section. It is on the eastern bank of the stream a few rods above the Cleveland, Southwestern & Columbus Ry. bridge and the house of Mr. Peter Shoon (spelled Spohn on his mail box). There is a marked anticlinal fold and the following section was measured near the center of the curve in the bank:

SECTION ON RATTLESNAKE CREEK NEAR EAST NORWALK

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
12.	Hard, slaty, black shale	17±	..	54	5
11.	Soft, olive to blue, argillaceous shale	2	2	37	5
10.	This is probably mostly blackish shale, but not so hard as the upper zone	7±	0	35	3
9.	Mainly soft argillaceous, blackish shale but at base hard, black shale	5	0	28	3
8.	Bluish-gray layer, 3 in. or less in thickness, with rather poor cone-in-cone structure. Higher on the bank is another cone-in-cone layer, but its position in one of the above zones was not determined	..	3−	23	3
7.	Black shale, on the second east bank above this section and about 1½ ft. above the subjacent zone of blue shale, is a more or less concretionary layer of cone-in-cone with a thickness varying from 0 to 3± in	6	0	23	0

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[1] *Geological Survey of Ohio*, III (1878), 304.

SECTION ON RATTLESNAKE CREEK NEAR EAST NORWALK—*Continued*

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
6.	Blue, soft, argillaceous shale containing small rusty concretions, and an irregular, lenticular one	2	3	17	0
5.	Three thin, blue, concretionary, sandy layers separated by blue shale and weathering to a rusty color	..	5±	14	9
4.	Olive shale	1	6	14	4
3.	Black or blackish shale containing a concretionary layer with fairly good cone-in-cone structure. It thins out here and there on the bank but after an interval reappears at the same stratigraphic horizon and varies in thickness from 0 to 1½ in. A thin band of blue shale, 2± in. thick was also noted in this zone of black shale	12	6	12	10
2.	Blue shale containing apparently a very thin layer, ¼ in. or so thick, of blue hard rock with a slight tendency to cone-in-cone structure	..	4±	..	4
1.	Black shale to bottom of creek. These lower two zones and a considerable part of the overlying 12½-ft. zone of black shale are only shown on the lower part of the bank at the axis of the fold	..	..	..	..

In the above section there is a layer of cone-in-cone in the black shale of zone No. 3 and even an imperfect one in the blue shale of zone No. 2; consequently if the layers of cone-in-cone are characteristic of the Cleveland shale, it appears that practically all of the above section is to be referred to that formation. Apparently all of the shale overlying the 2¼-ft. zone of blue shale (No. 6) with a thickness of nearly 37½ ft. ought to be referred to the Cleveland.

Farther up the creek on its western (southern) bank on the Frank Landoll farm the Berea sandstone is shown and the following section was measured:

SECTION ON RATTLESNAKE CREEK ON LANDOLL FARM

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
10.	*Berea sandstone:* Shaly to fairly massive sandstone, but more or less shattered and highly inclined to the west. The sandstone has more or less contorted or concretionary structure and there is also some shale, from 8 to 10 ft. shown. The lower layer is full of marcasite	9±	..	46	6
9.	Blue, argillaceous shale lithologically like the Bedford	2	6	37	6
8.	Covered interval	1	9±	35	0
7.	Bluish-gray, argillaceous shale lithologically like the Bedford	16	6	33	3
6.	Black, hard shale	1	2±	16	9
5.	Bluish-gray, argillaceous shale from 1½ to 2½ in. thick	..	2±	15	7
4.	Black, hard shale	1	9	15	5
3.	Bluish-gray, argillaceous, blocky shale lithologically like Bedford	4	0±	13	8
2.	Black, slaty shale lithologically like Cleveland	2	4	9	8
1.	Covered to creek level; but on the opposite bank just below the old stone bridge is black, slaty shale regarded as Cleveland, which contains numerous specimens of *Sporangites*	7	4	7	4

In the above section the blue to bluish-gray argillaceous shale of zones 7 and 9 certainly has the lithologic appearance and stratigraphic position of the Bedford. The black shale of zone No. 6 is lithologically like the Cleveland; but below is the 2±-in. layer of bluish-gray shale (zone No. 5), then 1 ft. 9 in. of back shale, (zone No. 4), below which is a 4-ft. zone of bluish-gray shale (No. 3), so that it is somewhat uncertain where the line between the Bedford and Cleveland ought to be drawn. A few rods below the locality of the above section are two abandoned quarries with walls from 30 to 40 ft. high. The barometer indicated that the water level in the first quarry is fully as low as the bed of the creek opposite the section where the base of the Berea sandstone is 37½ ft. above creek level. Mr. Landoll reported that a boring on the bank not far from the above section was all in "slate," no sandstone in it. This is evidently another example of channel filling and others may be seen on the banks of the creek farther up stream.

Vermilion River sections.—The next river east of the Huron is the Vermilion, which also has steep banks affording excellent sections. One of the most interesting is on its eastern bank at Rugby (formerly called Manchester and Mill Hollow), in Brownhelm Township, 18 miles northeast of Milan on the Huron River.

SECTION ON VERMILION RIVER AT RUGBY

No.		Thickness Ft.	Total Thickness Ft.
6.	*Bedford formation:* Near the bend of the river the upper part of the bank is composed of red shale with an estimated thickness of 20 ft	20±	140
5.	Buff to gray argillaceous shale with an occasional thin, harder layer. Measured on roadside up the hill west of the river	10	120
4.	Very hard, gray, fine-grained sandstone which weathers to a brownish color and becomes slightly rotten. Shown in gully on eastern bank just below Bacon Brothers' barn and by highway on western side with a thickness of from 5 to 6 in. Blocks of this sandstone are conspicuous on the steep bank above the Rugby River bridge.	½±	110
3.	Light to dark-gray, blue and buff, soft to rather hard argillaceous shale with a 1-ft. layer of thin-bedded, very compact argillaceous limestone which weathers to brown. Fossils occur in these shales the most abundantly at 3 ft. 8 in. above the base of the zone. The description and measurement for this zone are from the outcrops by the highway west of the river, where it is 6 ft. 5 in. thick	6½±	109½
2.	*Cleveland shale:* Black, slaty shale finely shown in river bank above the Rugby bridge. Perhaps there are some lighter-colored layers below the middle of this shale. The bank has that appearance as seen from the opposite side of the river, although it is difficult to be certain. In the gully below the Bacon Brothers' barn there is a covered interval of 13½ ft. from the base of the thin sandstone to the top of the first exposed black shale. From this horizon down to river level at the Rugby bridge is 76⅓ ft. as leveled by Mr. T.G. Roderick, the writer's assistant. If to this be added the additional 7 ft. of black shale to bring it up to the base of the Bedford as shown on the western side it will make it 83⅓ ft. Going up the river there is an anticlinal fold which near the bend brings up blue shale, and there are apparently about 8 ft. more of black shale to be added to the bank at the bridge, making altogether 91⅓ ft. of black shale	91⅓	103+
1.	"*Erie shale*" *of Newberry:* Blue shale and thin layers of blue micaceous sandstone, from 2 to 5 in. thick. At bend in river and to river level when water is low	11¾	11¾

Dr. Newberry stated in his description of the Erie shale that "toward the west it rapidly thins out and is lost sight of south and west of the Vermilion river.[1]"

Mr. Bacon stated that Mr. Terrell used to hunt for fossil fishes at this locality; that the largest number of specimens came from the bank above the bridge; that the horizon could be easily reached from the river level and would, therefore, be in the lower part of what is called the Cleveland shale in the above section.

A well was drilled on the Indian Fort farm, at the house of Mr. S. J. Leimbach, 1¼ miles south of Rugby, in the summer of 1912. The following data concerning it were furnished by Mr. Leimbach and Mr. Henry Schafer, who drilled it. The sandstone "shell" near the base of the Bedford was struck at a depth of 55 ft. and 7 ft. added to this would give 62 ft. for the depth of the top of the Cleveland shale. The Devonian limestone was reached at 670 ft., above which the driller reported 150 ft. of soft shale. In the well on the F. R. Morse farm, about one-fourth mile north of the Leimbach one, Mr. Schafer stated that there is a streak of bastard limestone 8 to 10 ft. thick about 20 ft. below the top of this soft shale. This hard zone is probably the Prout limestone, in which case the Olentangy shale is 120 ft. thick and 670 ft.–130 ft.+62 ft. leaves 478 ft. for the thickness of the Ohio Shale (Cleveland and Huron shale).

On the western side of the Vermilion River at the Cooper or Miles bridge, a mile below Rugby, is a conspicuous cliff of Cleveland shale. A few rods below the bridge is a gully in which the following section was measured:

SECTION ON VERMILION RIVER BELOW COOPER BRIDGE

No.		Thickness Ft.	Total Thickness Ft.
4.	*Cleveland shale:* This zone forms the conspicuous upper part of the cliff and is composed of black, slaty shale. In the gully, where 55 ft. are shown according to the barometer, all black except a one-half inch streak of soft, gray shale. On the highway up western bank near base of continuous black shale a calcareous, gray, lenticular layer 10 to 12 ft. long and about 2 in. thick with cone-in-cone structure. . . .	55±	87

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[1] *Geological Survey of Ohio*, I (1873), 163.

SECTION OF VERMILION RIVER BELOW COOPER BRIDGE—*Continued*

No.		Thickness Ft.	Thickness Total Ft.
3.	Alternating olive and blue layers of argillaceous shale with black, bituminous shale and thin layers of blue, micaceous sandstone. The light-colored layers of shale predominate	12½	32
2.	Black shale predominates but there are thin bands of light-gray shale with an occasional thin one of blue, micaceous sandstone	5½	19½
1.	Alluvium to river level	14	14

In the above section there is no evidence to show that the Cleveland shale extends below the base of the 55 ft. of black shale composing zone No. 4. The subjacent shales and thin sandstones may be referred to the Huron shale or its eastern equivalent, the Chagrin formation.

The following section was measured from outcrops by the highway climbing the eastern bank from the Cooper bridge:

SECTION ON VERMILION RIVER EAST OF COOPER BRIDGE

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
4.	*Bedford formation:* Gray, compact, and very hard sandstone, from 6 to 7 in. thick. Farther up the highway is chocolate-colored, argillaceous shale	..	6+	55	0
3.	Thin-bedded, blue, impure limestone alternating with shales	1	5	54	6
2.	Blue, argillaceous shale in upper part of zone; lower part composed of gray to drab, argillaceous shale	3	1	53	1
1.	*Cleveland shale:* Black, slaty shale containing two layers with cone-in-cone structure. The upper one is about 1 in. thick and may be traced for some distance in the shale. Considerably lower and near the base of the outcrop is the other one that is a lens of dark-gray, calcareous rock 8 ft. 10 in. long and near the center 4 in. thick, in which the cone-in-cone structure is well shown. The dip along the highway varies from 4° to 10° N. 40° W. Base of black shale not shown	50±	..	50	..

Black River sections.—To the east of Vermilion River is Black River, which is also bordered by high banks for much of its course northward from Elyria. On the eastern bank of Black River on the farm of the late Mary L. Demeiner (formerly known as the D. W. Garfield farm) in the extreme southern part of Sheffield Township, 3¾ miles north of Elyria and 11¾ miles northeast of the Rugby section on Vermilion River, is a steep cliff where the following section was measured. Its upper part is exposed by the northern side of the east-and-west highway a few rods below the Demeiner house.

SECTION ON BLACK RIVER ON DEMEINER FARM

No.	Thickness		Total Thickness	
	Ft.	In.	Ft.	In.
5. *Bedford formation:* Soft, rather light-gray, argillaceous shale, 4 to 5 in. shown...........	..	4½±	71	7
4. Dark-gray to blue, rather blocky shales containing the usual Bedford fauna. The fossils are most abundant in the upper part of the zone and *Parallelodon hamiltoniae* (Hall) is the most common species.........................	1	9½	71	2½
3. Soft, light-gray, argillaceous shale from 17 to 18 in. thick............................	1	6	69	5
2. Coarse, blocky, dark-gray to blackish, arenaceous shale containing some fossils, as *Spirifer* sp. and *Productus* sp.........................	..	11	67	11
1. *Cleveland shale:* Slaty shale, apparently all black. From river level to base of Bedford 60 ft. by barometer and 67 ft. as leveled by Mr. Charles S. Mead.........................	67	..	67	..

The 67 ft. of black shale in the above section all belong in the Cleveland and the base of the cliff apparently does not reach the top of the Huron or Chagrin shale.

There are steep banks composed mainly of black shale on the sides of the big bend in the Black River east of South Lorain. On the northern side at the "gap" about 1½ miles north of the Demeiner section the bank and outcrops on the highway are apparently all black shale and almost at the base is a calcareous lens 1½ inches thick at the middle, with cone-in-cone structure. These shales contain immense numbers of *Sporangites* which may be collected in the weathered, loose shales at the foot of the cliff. In the summer of 1912, when this locality was last visited, the river was high so that one could not follow along its lower bank. When it was visited in 1903 it was noted that the western bank shows several small anticlinal and synclinal folds. At a point about opposite the street running west there are 53 ft of black, slaty shale, apparently all Cleveland, capped by 4 ft. of drift. At the northern end of the cliff near the base it was stated that two layers of micaceous sandstone are brought up, and above these in black shale are at least two bands of soft, olive, argillaceous shale from 2 to 3 in. thick. The lower olive band is about 6 ft. above the upper sandstone stratum. These bands of olive shale are stratigraphically below the base of the 53-ft. bank of black shale and at the northern end of the cliff perhaps 10 ft. of shale stratigraphically lower than the 53-ft. bank are shown.

SHORE OF LAKE ERIE FROM LAKE BREEZE HOUSE TO EAGLE CLIFF VILLAGE

Section near Lake Breeze House.—The lake shore east of the mouth of Black River for nearly 4 miles is said to be composed of drift and soil. Below the grounds of the old Lake Breeze House shales and sandstones appear and the lake shore from this locality eastward is called "iron-bound," on account of the general presence of rock cliffs. The following section was measured on the cliff east of the Lake Breeze House grounds and below the brick schoolhouse in Sheffield Township:

SECTION EAST OF LAKE BREEZE HOUSE

	THICKNESS		TOTAL THICKNESS	
	Ft.	In.	Ft.	In.
14. Bowlder clay to top of cliff	10±	..	15	3
13. Black, bituminous shale which on weathering splits up into thin laminae; the edges are rusty with efflorescence of sulphate of iron (melanterite, $FeSO_4 \cdot 7(H_2O)$)	2	10	5	3
12. Soft, gray, argillaceous shale	..	1	2	5
11. Blue, hard, sandy shale	..	1+	2	4
10. Soft, gray shale	..	1−	2	3
9. Blue, compact, very fine-grained sandstone, from 4 to 5 in. thick. Fossil fish in black shale below this sandstone	..	4½	2	2

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
8.	Black shale from 2½ to 3½ in. thick	..	3	1	9½
7.	Soft, gray, argillaceous shale containing two thin layers of black shale	..	3	1	6½
6.	Black shale	..	1½	1	3½
5.	Thin layer of bluish sandstone	..	¾	1	2
4.	Black shale	..	8½	1	1¼
3.	Gray, argillaceous shale	..	1¼	..	4¾
2.	Black shale	..	2½	..	3½
1.	Blue to gray, argillaceous shale and base of shale exposed on lake bank	..	1	..	1

Judging from those studied farther east, all of the shales in the above section are below the base of the Cleveland, with the possible exception of the black shale of zone No. 13.

Mr. Charles Maddock, who lives just west of the Lake Breeze House and formerly collected specimens of fossil fish with the late Mr. Jay Terrell at this locality, said that most of the specimens came from the black shale below the thin sandstone layer of zone No. 9. This indicates that those specimens reported by Mr. Terrell from the lake shore near the Lake Breeze House came from the upper part of the Huron shale which farther east is equivalent, stratigraphically, to the upper part of the Chagrin formation.

Dr. Newberry at first referred these fish-bearing shales to the Huron and stated that:

> the most interesting specimens found in this locality have rewarded the laborious and intelligent search of Mr. J. Terrell, the proprietor of the Lake Breeze House, situated in the immediate vicinity of the outcrop of the fish-bearing stratum.[1] . . . . These specimens we owe to the enthusiasm and intelligence of Mr. Jay Terrell, who found them at his home in Sheffield, Lorain Co. Here the upper portion of the Huron shale forms, along the Lake Shore, cliffs, which are being constantly worn away by the waves. These cliffs have been Mr. Terrell's favorite hunting ground, and as the erosion of the surface revealed here and there the projecting point of a bone, each indication has been followed up with care, and the bone taken out.[2] . . . . The large number of specimens since obtained, and, indeed, all the remains of *Dinichthys* hitherto taken from the summit of the Huron shale at Sheffield, belong, as we now know, to this species [*D. terrelli*], which is quite distinct from that found at the base of the formation at Delaware [*D. herzeri*].[3]

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[1] *Geological Survey of Ohio*, II (1874), 214, also see I (1873), 157.

[2] *Ibid.*, II, Pt. II, Palæontology (1875), 3.

[3] *Ibid.*, p. 4.

Later, Dr. Newberry changed his opinion concerning the age of these fish-bearing shales and wrote as follows:

> This dip misled us, and the thinning of the Erie shale, bringing the Cleveland down near to the Huron, caused these two to be confounded, and led to the supposition that the fish-bearing black shales which form the lake shore in Lorain County were the upper part of the Huron; hence all the great Placoderms discovered by Mr. Terrell were at first referred to that formation. This matter was, however, cleared up by an excursion made by the writer westward from Cleveland in 1886, and it is now definitely established that all the outcrops of black shale in Cuyahoga and Lorain Counties belong to the Cleveland shale, and that none of the fossil fishes described from northern Ohio should be credited to the Huron.[1]

Section on Aaron Hill farm.—The following section was measured at a little gully on the Aaron Hill farm a few rods east of the end of the Harris road and one mile northeast of the Lake Breeze House:

LAKE SHORE SECTION ON THE AARON HILL FARM

No.		THICKNESS		TOTAL THICKNESS	
		Ft.	In.	Ft.	In.
11.	Bowlder clay with soil at top	5	..	18	8½
10.	All black, slaty, bituminous shale. In the shale a lens of coal 1¾ in. thick, 3 ft. long, and 3⅓ ft. above the sandstone layer of zone No. 6	11	5	13	8½
9.	Blue, argillaceous shale from 1 to 1¾ in. thick	..	1½±	2	3½
8.	Sandstone layer from 0 to 1¼ in. thick	..	1±	2	2
7.	Blue to gray, argillaceous shale	..	1½	2	1
6.	Blue, compact, micaceous, laminated sandstone layer, from 3 to 6 in. thick, which is the conspicuous one on this part of the lake shore	..	4½±	1	11½
5.	Black shale from 4 to 5 in. thick	..	4½±	1	7
4.	Soft, gray shale from 2 to 3 in. thick with a streak of black shale at the middle of the zone from ¼ to ½ in. thick	..	2½±	1	2½
3.	Black shale	..	5	1	0
2.	Bluish-gray argillaceous and arenaceous shale	..	1	..	7
1.	Black shale to lake level	..	6	..	6

The above section is about north of the Aaron Hill farmhouse, and a little farther east than opposite his barn the sandstone layer of zone No. 6 is at lake level. This is a dip of 1½ ft. in a horizontal distance of 375 ft. The sandstone reappears in the cliff a little farther east than opposite the first farmhouse east of the Hill's. This shows a small synclinal fold and as the shore is followed eastward to Beach Park and beyond there is seen a succession of small anticlinal and synclinal folds as has been described by Dr. Kindle. He states:

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[1] *Monograph U.S. Geological Survey*, XVI (1889), 127.

> With few exceptions these structures have very low arches, nearly flat on top, which rise above their troughs from 3 to 8 feet. The width of these gentle undulations usually ranges between 200 and 350 yards, giving an effect not unlike the billowy surface of a subsiding sea. An exceptionally high arch just west of Eagle Point and another at Beach Park rise 20 feet or more. Detailed study of this lake shore section has shown that the east and west limbs of the series of low anticlinal rolls which succeed each other for more than 8 miles are essentially equal, and that for this distance the base of the Cleveland shale shows no westerly declination between Eagle Cliff and Lake Breeze.[1]

The sandstone of zone No. 6 of the above section is an easy one to follow along the lake cliff as long as it is above water or soon reappears in this succession of anticlinal and synclinal folds. It is a blue to bluish-gray, laminated sandstone which splits up into thinner layers, so that it may be called platy, and when it reaches lake level it breaks out in large rectangular slabs. The main line of joints run about 70° W. of N.

Section on L. B. Ellis farm.—Another lake-shore section was measured on the L. B. Ellis farm, which is about two miles southwest of Beach Park.

LAKE SHORE SECTION ON THE S. B. ELLIS FARM

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
12.	Black, slaty, bituminous shale. A cone-in-cone lens almost at the base of this zone	6	6	14	4
11.	Soft, gray and blue, argillaceous shale	..	4¾	7	10
10.	Black shale	..	¾	7	5¼
9.	Soft, blue to gray, argillaceous shale	..	3	7	4½
8.	Black, bituminous shale	..	¾	7	1½
7.	Soft, blue to gray, argillaceous shale. The total thickness of these gray to blue and black layers of shale between zones 6 and 12 of thick black shale is 12¾ in.	..	3½	7	¾

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[1] *American Journal of Science,* 4th ser., XXXIV, 207, 208.

LAKE SHORE SECTION ON THE S. B. ELLIS FARM—*Continued*

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
6.	Black, slaty, bituminous shale with marcasite concretions	4	10	6	9¼
5.	Soft, blue shale from 3½ to 4 in. thick in which in places near the center of the zone is a little harder material	..	3¾±	1	11¼
4.	Blue, micaceous, laminated, platy sandstone layer, from 2 to 6 in. thick. Both the top and bottom surfaces appear to be uneven so that the thickness of the layer is variable. The conspicuous sandstone layer with numerous loose blocks along this part of the beach	..	4±	1	7½
3.	Black shale	..	3½	1	3½
2.	Soft, blue, argillaceous shale with an inch band of black shale in the center	..	5	1	0
1.	Black shale to lake level	..	7	..	7

The 12¾-inch zone of gray to blue and black shales between zones 6 and 12 of thick black shale shows the appearance of the gray to blue soft shale at a higher stratigraphic position than in the sections toward the Lake Breeze House. For example, in the section on the Hill farm above the conspicuous sandstone zone are from 2½ to 4½ in. of blue, argillaceous shale and sandstone, and then the 11 ft. 5 in. of black shale extending to the top of the shale outcrop. In this section there are from 3½ to 4 in. of blue shale above the conspicuous sandstone, then 4 ft. 10 in. of black shale overlaid by the 12¾ in. of gray to blue and black shale, capped by 6½ ft. of black shale near the base of which is a cone-in-cone layer. This upper zone of black shale, No. 12, certainly appears to belong in the Cleveland.

Beach Park section.—In the western part of Beach Park, just west of the bathing beach, a marked anticlinal fold brings up the rocks for some thickness below the conspicuous sandstone layer, which at this locality appears at the top of the bank until it disappears toward the axis of the fold.

LAKE SHORE SECTION IN WESTERN PART OF BEACH PARK

No.		THICKNESS		TOTAL THICKNESS	
		Ft.	In.	Ft.	In.
6.	Blue, micaceous, laminated, platy sandstone, which is near top of bank, continues on up to the top and is worn away toward the axis of the fold	..	6	13	8¼
5.	Alternating gray to blue, argillaceous and black shale	6	11	13	2¼
4.	Blue, thin sandstone from 1¼ to 2 in. thick	..	1½±	6	3¼
3.	Blue to gray and black shale from 6 to 7 in. thick	..	6½	6	1¾
2.	Blue, thin sandstone from 1½ to 3 in. thick	..	2¼±	5	7¼
1.	Mainly gray to blue, argillaceous shale with some thin layers of black shale. Lenticular layers of clay ironstone occur in these soft shales, which are like those in the Chagrin formation in the western part of Cleveland. Layer of blue, thin sandstone near base of section. Lake level	5	5	5	5

All of the above section closely resembles lithologically the Chagrin formation as shown along the lake shore to the west of Cleveland and Rocky River. A view of the eastern limb of this anticlinal fold to the east of the bathhouse is shown in Fig. 6.

Avon Point Cliffs.—The blue, conspicuous sandstone was followed in the cliffs bordering the lake to almost opposite the northern end of the road running south to Avon Center, about one-fourth mile southwest of Avon Point. The writer is uncertain whether this sandstone shows or not in the cliffs at Avon Point; but to the east of Avon Point in Avon Lake it has thinned to a somewhat concretionary layer from a fraction of an inch to 2 in thickness. Two ft. or more below is another thin sandstone and 4± ft. below that is a zone of three sandstones separated by 8 or 9 in. of shale. Still lower, not far above lake level, are several thin sandstones and the lower shales contain lenticular ironstone concretions. At this locality there are 10 ft. or more of apparently black Cleveland shale forming the upper part of the cliff, below which are some 15 ft.

of blue to gray shale with thin bands of black shale containing layers of sandstone from 1 to 2 in. thick, all of which is referred to the Chagrin formation. This cliff is at the D. E. Parsons cottage in Avon Lake at stop 50 on the Lake Shore Electric Ry. a few rods east of the brick schoolhouse of Avon District No. 4. It is three-fourths of a mile southeast of Avon Point and about one and one-half miles northwest of the western end of Eagle Cliff. The rocks are dipping easterly; but east of Avon Point they lie much more nearly horizontal than to the west of it where there is so much folding.

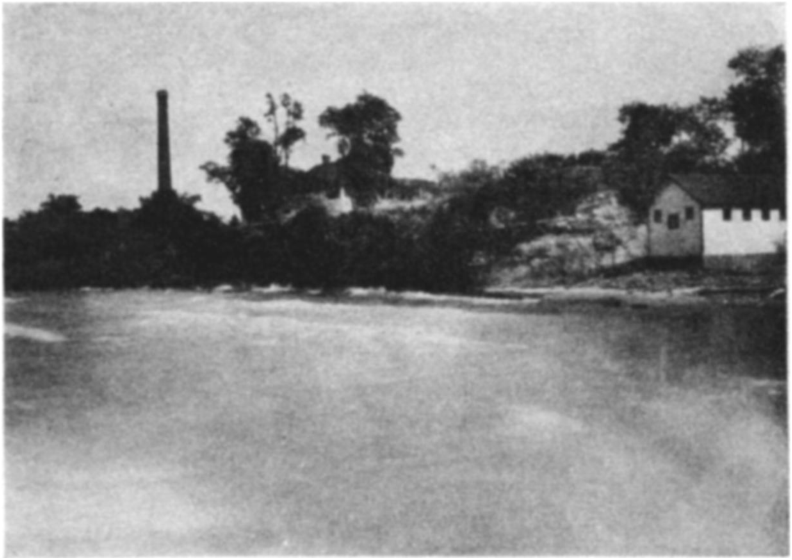

FIG. 6.—Cliff of Huron shale = Chagrin at Beach Park on shore of Lake Erie, showing one limb of anticlinal fold.

Section opposite house of John Goetz.—The following section was measured opposite the house of Mr. John Goetz about one mile west of the western end of Eagle Cliff:

LAKE SHORE SECTION OPPOSITE HOUSE OF JOHN GOETZ

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
12.	Drift and soil	3	6	37	10
11.	*Cleveland shale:* Apparently all black, slaty, bituminous shale	19	6	34	4
10.	*Chagrin formation:* Blue, thin sandstone	..	1	14	10
9.	Gray and black shale, alternating	..	11	14	9
8.	Blue, thin sandstone from 1 to 1¾ in. thick	..	1½±	13	10
7.	Gray and black shale, alternating	2	7	13	8½
6.	Blue, thin sandstone from 1 to 2 in. thick	..	1½±	11	1½
5.	Soft, gray, argillaceous shale with thin layers of black shale. More or less concretionary layers of thin sandstone occur at irregular intervals	6	9½	11	0
4.	Blue, laminated sandstone from 2½ to 3½ in. thick	..	3	4	2½
3.	Gray and black shale	..	3	3	11½
2.	Blue, thin sandstone from ½ to 2½ in. thick	..	1½±	3	8½
1.	Gray and black shale with thin layers of somewhat concretionary sandstone to lake level	3	7	3	7

The 19½ ft. of upper black shale in the above section clearly appear to belong in the Cleveland shale, and the subjacent shales and sandstones the writer refers to the Chagrin.

Section at western end of Eagle Cliff Village.—A mile farther to the southeast the following section was measured at the house of Mr. W. T. Hinz, which is the most eastern one in Avon Township; just to the east is the western end of Eagle Cliff Village of Dover Township.

LAKE SHORE SECTION AT THE HOUSE OF W. T. HINZ

No.		Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
4.	Drift and soil	4	..	47	8
3.	*Cleveland shale:* Apparently all black, slaty, bituminous shale	34	..	43	8
2.	*Chagrin formation:* Blue sandstone and arenaceous shale	..	2	9	8
1.	Soft, blue to gray, argillaceous shale alternating with thin layers of black shale. There are also thin layers of blue sandstone. Lake level	9	6	9	6

It will be noticed that the cliffs increase in height as followed eastward from the Lake Breeze House to Eagle Cliff. The cliff at the Goetz house, one mile northwest of Eagle Cliff, is nearly 38 ft. high and the one just west of Eagle Cliff 47⅔. These higher cliffs also show a greater thickness of the Cleveland shale, as, for example, 34 ft. in the Hinz Cliff, 19½ in the Goetz, and in the low cliffs near Lake Breeze only a few feet at most.

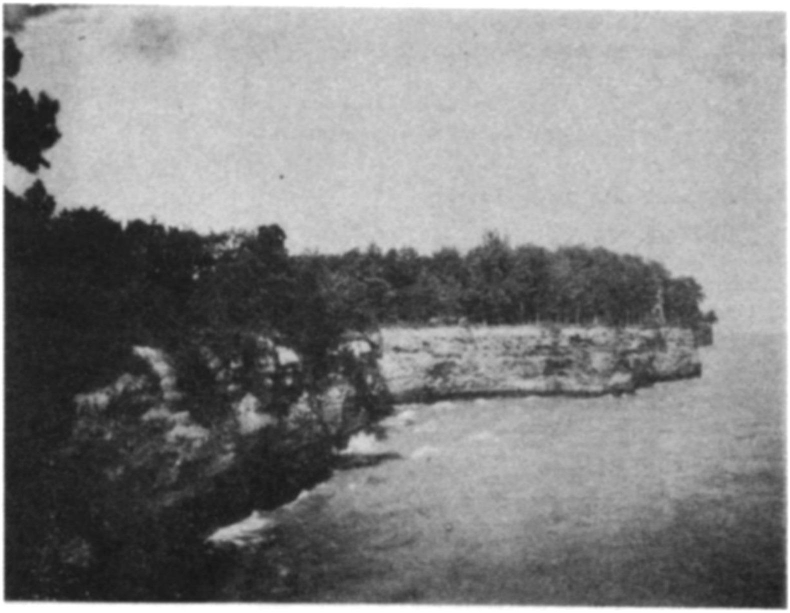

FIG. 7.—Cliff at eastern end of Eagle Cliff Park on shore of Lake Erie. Upper part of cliff Cleveland shale; lower part Chagrin = Huron.

A view of the shore of Lake Erie at the eastern end of Eagle Cliff is shown in Fig. 7, where the upper part of the cliff is composed of Cleveland shale and the lower part of Chagrin = Huron shale.

The cliffs along the lake shore from Eagle Cliff eastward to Rocky River, the banks of this river, the lake shore cliffs in the western part of Cleveland, and many sections on the streams east of Cleveland have recently been described in Bulletin 15, 4th series of the *Geological Survey of Ohio*, to which the reader is referred for a detailed description of these formations in that part of the state.

CONCLUSIONS

It has been shown in Bulletin 15 of the *Geological Survey of Ohio* that the Cleveland shale in the Cleveland region is underlaid by the Chagrin and overlaid by the Bedford formation. The upper part of the Chagrin formation in the Cuyahoga Valley and to the eastward contains a marine molluscan fauna concerning the age of which there appears to be a general agreement that it represents the Chemung of southern New York which belongs in the upper Devonian. The basal part of the Bedford formation also contains a marine molluscan fauna which has been found as far west as both sides of the Vermilion River and is also present in central Ohio. The weight of evidence also appears to support the reference of this fauna to the Devonian which has been effectively presented in a recent paper by Dr. Girty.[1]

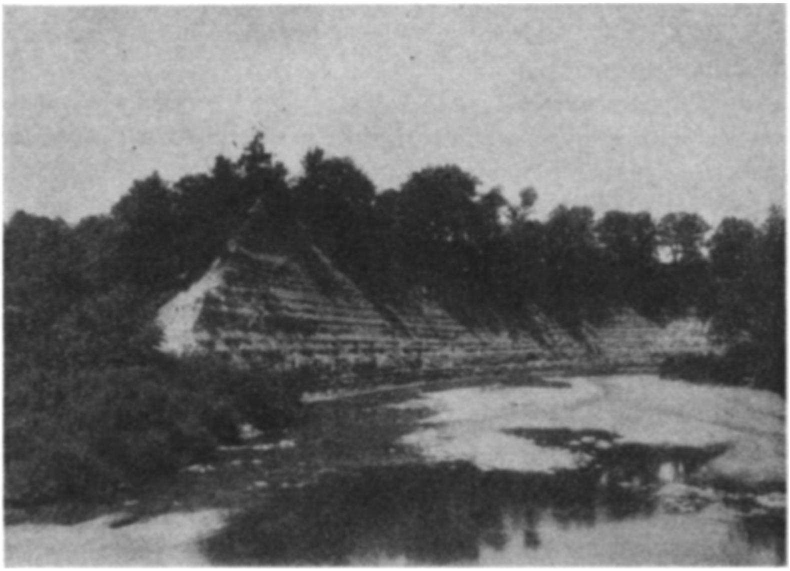

FIG. 8.—Cleveland shale at junction of East Branch and West Branch of Rocky River at Olmsted.

In Bulletin 15 in connection with the present paper, it is shown how, as the Chagrin formation is followed westward from Rocky River along the lake shore and in the stream valleys, that thin layers of black shale appear in the typical blue and gray shales of the Chagrin. These alternating layers of blue and black shales were found in the lower courses of the Black and Vermilion rivers, while on the Huron River, the typical locality of the Huron shale, it was seen that this formation consists of a certain number of zones of practically pure black shale alternating with those that are composed of generally rather thin zones of blue to gray shale alternating with black shale. The formation has a thickness of over 200 ft. in the Huron River region and the thick zones of black shale contain spherical concretions of variable size. The invertebrate, vertebrate, and plant fossils contained in the Huron shale are of Devonian age according to the opinions of at least most paleontologists who have recently studied them.[1] The Cleveland, composed mainly of black, bituminous shale containing lens-shaped layers with cone-in-cone structure and without spherical concretions, overlies the Chagrin formation in the Cleveland region and on Rocky River, while to the west in other streams or in the cliffs of the lake shore nearly, if not quite, as far as Lake Breeze it overlies the alternating blue to gray and black shales with thin sandstones. The Cleveland shale overlies similar alternating shales in the Black and Vermilion river valleys and the Huron shale in the Norwalk region. The thickness of the Bedford formation is variable in all this region, largely due to the erosion of its upper surface before the deposition of the Berea sandstone, which was perhaps in general greatest in the Norwalk region where frequently all of the formation is wanting and at most only the lower part remains. The Bedford fauna and the disconformity between the Bedford or Ohio shale and Berea formations favors drawing the line of separation between the Devonian and Mississippian at this horizon. It appears clear that the upper black shale crossing this district is the Cleveland, that the Huron shale in general is the western lithologically more or less changed stratigraphic equivalent of the Chagrin formation, and that both the stratigraphic and paleontologic evidence agree in referring it to the Devonian.

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[1] *Annals New York Academy of Sciences*, XXI, 295–319.

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[1] For a summary of these opinions see *Geological Survey of Ohio*, Bulletin 15, chap. vi, 509–29.